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Conceptualizing the acceptance of wind and solar electricity

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ABSTRACT

Drawing from research interviews and the academic literature, this article conceptualizes the conditions that promote investor confidence and the social acceptance of wind and solar sources of electricity. It explores the factors influencing the acceptance of commercial wind turbines in Denmark and India and residential solar panels in Germany and the United States. The article begins by justifying its selection of case studies and explaining the methodology behind its research interviews and field visits. It then summarizes some of the key findings in recent surveys of public attitudes and market acceptance concerning renewable energy, with a focus on why some investors and communities reject wind and solar systems whereas others rapidly approve and adopt them. The article proposes that acceptance has multiple dimensions – socio-political, community, and market – that must be met holistically in order for investors and users to embrace renewable energy. The article argues that acceptance hinges upon the prevalence of nine factors; the lack of such factors creates environments where they are rejected. The theory is tested against four case studies that explore the forces driving renewable energy in Denmark, Germany, India, and the United States.

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1. Introduction

In his extensive assessment of electricity generation in eight European countries – Austria, Belgium, Germany, Ireland, Italy, Netherlands, Spain, and the United Kingdom – Patrik Soderholm found that economic motivations and "rational" economic behavior could not adequately explain differences in electricity generation technology and structure [1]. Instead, Soderholm noted that far more obtuse political and social factors, such as public opposition to nuclear power, subsidies for different energy sectors, and constraints on institutional capacity, exerted considerable influence in how each country pursued a different portfolio of technologies and regulations. Other historical examples make this point more forcefully. Without shortages of coal during World War I, the Great Depression and the New Deal, the United States may never have embarked upon large-scale hydroelectric projects in the 1930s [2]. Without World War II, the French notion of *dirigisme*, and the

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connection between post-war construction and national identity, France may never have pursued atomic energy in the 1950s and 1960s [3].

While such anecdotes are useful at identifying the broad political and social factors that can shift national directions in energy policy, they leave unanswered an important and far more nuanced question: What technical, social, economic, and political conditions promote the acceptance of particular forms of electricity supply? In response, this article explores the factors influencing the acceptance of commercial wind turbines in Denmark and India and residential solar panels in Germany and the United States.

The article begins by justifying the selection of case studies and explaining its methods of data collection, primarily relying on research interviews and field visits. It then summarizes some of the key findings in recent surveys of public attitudes and market acceptance concerning renewable energy, with a focus on why some investors and communities reject wind and solar systems whereas others rapidly approve and adopt them. The article proposes that acceptance has multiple dimensions – socio-political, community, and market – that must be met holistically in order for investors and users to embrace renewable energy.

More specifically, the article argues that acceptance therefore hinges upon the prevalence of nine factors: (1) strong institutional capacity; (2) political commitment; (3) favorable legal and regulatory frameworks; (4) competitive installation and/or production costs; (5) mechanisms for information and feedback; (6) access to financing; (7) prolific community and/or individual ownership and use; (8) participatory project siting; and (9) recognition of externalities or positive public image. The presence of these nine factors is proposed to create market environments where wind and solar are accepted; the lack of them engenders environments where they are rejected. The theory is tested against four case studies that explore the forces driving renewable energy in Denmark, Germany, India, and the United States.

2. Research and theoretical methods

In searching for case studies, the authors wanted to include a mix of sectors, technologies, and countries. We selected the commercial wind sector because modern wind turbines are somewhat large-scale (in the range of 700 kW to 3 MW), are always grid-connected, represent one of the fastest growing global markets for renewable energy, and are generally utilized by electric utilities and independent power providers to generate electricity for wholesale customers. Residential solar panels, by contrast, are smaller in scale (in the range of a few Watts up to 10 kW), are sometimes off-grid, and are generally utilized by homeowners, cooperatives, and business firms outside of the energy sector to produce electricity for their own use (or to sell it back to the grid at retail or premium rates). We selected Denmark, Germany, India, and the United States because the countries represent a sample of developed and developing economies, different political institutions, and diverse geographic locations and areas.

To collect primary data related to the acceptance of renewable electricity in these four countries, the authors relied predominately on 149 research interviews at 89 institutions. Over the course of 2006 to 2009, one of the authors conducted 109 research interviews, 58 in the United States as part of the author's dissertation, another 23 as part of a fact finding mission to Denmark, and 28 on a similar fact finding mission to Germany [4–6]. Over the course of 2004 to 2006, the other author conducted 40 research interviews in India, primarily as part of her dissertation [7,8].

When arranging interviews and meetings, the authors took special care to include a variety of stakeholders in the energy research and diffusion process, including:

- Investor-owned electric utilities, independent power providers, independent system operators, and energy trading firms such as Southern California Edison, American Electric Power, Exelon, EnergiNet DK, and Karnataka Power Transmission Corporation Limited;
- Universities and academic institutions such as the University of California-Berkeley, Cambridge University and the Indian Institute of Technology, Madras;
- Nongovernmental organizations and consulting firms such as the German Solar Industry Association, Electric Power Research Institute, Ramboll, and the Indian Wind Turbine Manufacturers Association;
- Research institutes such as Oak Ridge National Laboratory, Risø National Laboratory in Denmark, Fraunhofer-Institut für Solare Energiesysteme in Germany, and The Energy Resources Institute in India;
- Regulatory agencies and government ministries such as the U.S. Department of Energy, U.S. Environmental Protection Agency, Danish Energy Authority, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), Maharashtra State Electricity Board, Tamil Nadu Electricity Regulatory Commission, and Ministry of New and Renewable Energy in India;
- Companies and manufacturers such as LM Glasfiber, Vestas, Enercon, Dong Energy, and Suzlon Energy India.

While a variety of open-ended questions were asked during these meetings, the most important for this study included "What explains the rapid adoption of renewable energy, and what impedes it?"; "What policies and factors have been most effective at driving the acceptance of wind energy and solar energy?"; "What are the main drivers of investment and technology transfer?"; "How are the concerns of multiple stakeholders addressed when creating policies for wind and solar energy?"; and "What can other countries learn from the experiences in Europe and North America concerning the acceptance of renewable energy?" Although many of these interviews were recorded and most have been fully transcribed, to encourage candor and protect confidentiality, we have presented such data as anonymous. We have basically perused the hundreds of pages of data from our interviews and plucked qualified statements that support our conceptual framework and case studies below. Unless otherwise indicated, all of the data referenced below comes from these research interviews, although it is impossible to ascribe particular comments and views to specific individuals. More details about these interviews are presented in Appendix A.

Relying on a qualitative method such as research interviews does have its drawbacks. Responses are difficult to code and answers vary by participant. Some respondents may provide socially desirable responses, telling researchers what they think they want to hear. But research interviews also possess advantages [9,10]. They escape the limits of rigidly defined tools and models, and can facilitate a more complete flow of knowledge as answers are not confined to the responses and categories anticipated by the researcher. Moreover, they are more flexible, enabling the investigator to adjust questions during the conversation and follow through to provide more complete answers. Lastly, research interviews are one of the only ways to deal with value laden and subjective issues. Many studies using quantitative tools and models make it difficult to account for nuance and variance, and they also rarely look at aspects (such as acceptance) which are difficult to quantify.

Our research meetings and interviews were supplemented with site visits to five cities in Denmark (Copenhagen, Kolding, Randers, Roskilde, and Virum), seven states in the U.S. (California, Colorado, Illinois, New York, Tennessee, Virginia, Washington) along with Washington, DC, four cities in Germany (Berlin, Hamburg, Freiberg, and Stuttgart), and four States in India (Tamilnadu, Maharashtra, Karnataka and Gujarat) and New Delhi.

To appreciate the perspective of wind and solar energy researchers, operators, users, and electricity suppliers, as part of these trips one of the authors visited the 576 MW (MW) wind farm at Altamont Pass in California; the 29 MW wind farm at Buffalo Mountain in Tennessee; the National Wind Technology Center near Boulder, Colorado; the Solar Outdoor Testing Facility at the National Renewable Energy Laboratory in Golden, Colorado; the 40 MW Middelgrunden offshore wind farm near Copenhagen; and the Wind Testing Facility at Risø National Laboratory. The other author visited several single wind turbine wind installations in India as well as the 125 MW wind farm in Chitradurga, Karnataka; the 12 MW wind farm in Tenkasi; and the wind masts installed by the Center for Wind Energy Technology in Chennai and the Palghat Pass. The meetings, interviews, and visits were supplemented with a review of the academic literature concerning renewable energy, especially drawing from journals such as *Energy Policy* and *Energy—The International Journal*.

3. Conceptualizing the acceptance of renewable electricity

While the literature explaining or describing the market penetration of renewable resources is vast and growing, this section summarizes a few exemplars of scholarship in the past few years and draws from these to develop a preliminary theory of social and market acceptance. Most helpful here have been three types of studies: those looking at national styles of regulation, those analyzing the barriers to renewable energy, and those looking at the factors that drive local acceptance and opposition to renewable energy, often through surveys of public attitudes and beliefs.

As an example of scholarship looking at national differences, Jacobsson and Lauber and Laird and Stefes have written thoughtful commentaries on the trends driving the acceptance of renewable energy in Europe and North America [11,12]. Their work has shown that social, technical, political, and economic factors have often coalesced together to explain why countries such as Germany the United States have successfully (or unsuccessfully) supported wind and solar systems. Their research has noted that "conventional" explanations behind such support, such as renewable resource endowments, public opinion in favor of renewable energy, large and sophisticated manufacturing sectors, and a history of investment in energy research, do not adequately account for why Germany has aggressively supported renewables whereas support in the United States has been mixed and inconsistent. Instead, factors such as an election system based on proportional representation that enhances access to small third parties, the experience of elevated radiation levels during Chernobyl and the discrediting of nuclear power by a strong social movement coupled with early concern about climate change, European Union constraints on subsidies for coal, reunification efforts that "distracted" conventional energy companies, and the ability for renewable energy industries to offset high rates of unemployment in Eastern Germany played a part in pushing renewable energy in Germany. By contrast, a political system easily captured by lobbyists with no sustained support for a green or environmental party, lack of leadership on climate change, profligate subsidies for coal, and strong opposition from energy companies impeded efforts in the United States.

Similarly, Haas and his colleagues explored the broad factors influencing why a set of 18 countries adopted different types of renewable policy mechanisms, and noted that "pro-renewable" environments could largely be explained by political and cultural style, the importance of energy security, and the absence of a strong conventional energy industry [13]. They noted that countries with a market oriented culture and liberalistic government often chose mechanisms that integrated well with existing markets and regulatory structures and offered premium incentives for investors. They argued that the countries concerned about energy security and/or climate change issues were more likely to embrace renewable energy, especially countries that had "meager" domestic resources of coal and oil. And they suggested that the absence of a strong conventional energy industry, countries that lacked major manufacturing capabilities in fossil and nuclear power, tended to be strong proponents of renewable energy industry.

A second line of scholarship relates to the barriers to renewable energy technologies. Sovacool looked at the technical and social barriers to renewable energy in the United States and found a variety of impediments including a dearth of high quality information about renewable electricity technologies and performance among users and producers, highly distorted price signals that failed to account for the benefits of renewables and the costs from conventional sources, political regulations that favored incumbent firms and energy providers, and cultural and behavioral challenges relating to aesthetic objections and a misunderstanding about how renewable systems work [4]. Beck and Martinot also surveyed the barriers to renewable energy worldwide and identified subsidies for conventional forms of energy, high initial capital costs, imperfect capital markets, lack of skills or information, technology prejudice, financing risks and uncertainties, high transaction costs, and a variety of regulatory and institutional factors as the primary culprits [14].

A third area of scholarship has been those studies looking at the local acceptance (or opposition) to renewable energy projects, especially wind farms [15–20]. This research, focusing mostly on public attitudes towards renewable electricity in Canada, Denmark, Germany, Ireland, the Netherlands, Sweden, United Kingdom, and the United States has noted that people with no specific experience with renewables are more likely to oppose them, overestimate their costs, and underestimate their benefits. The more expensive a group of people perceive a particular project the more they are likely to oppose it in their community. The same person or group can simultaneously support the *idea* of wind power (holding a positive view) but oppose the construction of a *particular* wind farm (holding a negative view), creating a "gap" between public support and private behavior. Opposition to wind projects changes significantly before and after projects are completed, with projects contentious at the planning stage but generally accepted after they have been constructed. Put another way, local people become more favorable towards wind farms after their construction and the degree of acceptance tends to increase in proximity to the wind farm. Providing incentives for local citizens to invest in or own part of a project, or inviting them to participate in planning and siting procedures, can strongly influence public acceptance. Greenberg, for instance, surveyed more than 2700 residents in the United States and found that familiarity with type of energy and proximity to a site were strong indicators of public acceptance, that greater concern about local environmental conditions showed a strong correlation with a preference for renewables and against fossil fuels, and that those participants that trusted authoritative institutions such as government and energy suppliers were usually supportive of coal and nuclear technologies [21].

While synthetic work drawing from each of these scholastic areas is less common, Wustenhagen et al. have proposed that the acceptance of renewable energy has at least three dimensions: socio-political, community, and market [22]. Socio-political acceptance is the broadest and the most general, and it concerns the ability for regulators, policymakers, and other key stakeholders to craft effective policies or frameworks that create and foster community and market acceptance below. Community acceptance is the most specific, and it involves the extent that projects are undertaken or invested in by local stakeholders, how costs and benefits are shared, and how policymaking is conducted. Market acceptance operates at a meso level between national politics and local communities, involving consumers (that must adopt a technology) and investors (that want to support its manufacturing and use). Fig. 1 shows how these three dimensions operate as a sort of nexus or triangle, implying that each form of acceptance is insufficient on its own to promote renewable energy; only environments where national social and political frameworks align with community interests and market drivers will see renewable energy rapidly adopted.

Drawing from this work and the studies above, we propose a conceptual framework consisting of nine factors to explain the acceptance of renewable electricity resources. Depicted in Fig. 2 and Table 1, we believe that acceptance hinges upon the prevalence of nine criteria that each correspond to socio-political, community, and market factors. Let us offer four caveats and details about our nine criteria.

First, we subscribe to the notion that all energy technology (and indeed, all technology) is social and technical, or socio-technical. For any technology to be embraced, a "seamless web" of technical, political, economic, and social conditions must simultaneously and synergistically exist [23]. This means that reliable technology is a precondition for all nine criteria, and is thus not placed in any of our three dimensions (although it is partially subsumed by competitive costs, since a poorly designed or unreliable technology would ostensibly cost more). It also means that all or most of our nine criteria are needed for acceptance to occur, in order for the "seamless web" to engender technology use.

Second, many of our criteria are interrelated, or at least have strong interactive effects between them. This is because we tried to be both mutually exclusive (each criterion is distinct from the others) with being collectively exhaustive (including a comprehensive list of metrics). In doing so, we have in essence blended together "producing" and "installing," since "use" requires both to have happened. We have also blended together "individual" and "community" use together since these occur at a scale below the country or state/province.

Third, we treat acceptance as relative and different from diffusion. Our criteria and conditions are not believed to facilitate absolute acceptance, which would imply total market saturation, but an accelerated level of diffusion compared to other countries and places. Diffusion is a neutral term, in this case having large numbers of renewable energy systems installed (and high installed capacity or production per capita). The term acceptance is social, and refers to the diverse technical, social, political, and economic factors driving (or even constraining) diffusion. Acceptance of renewable energy need not imply that such technologies

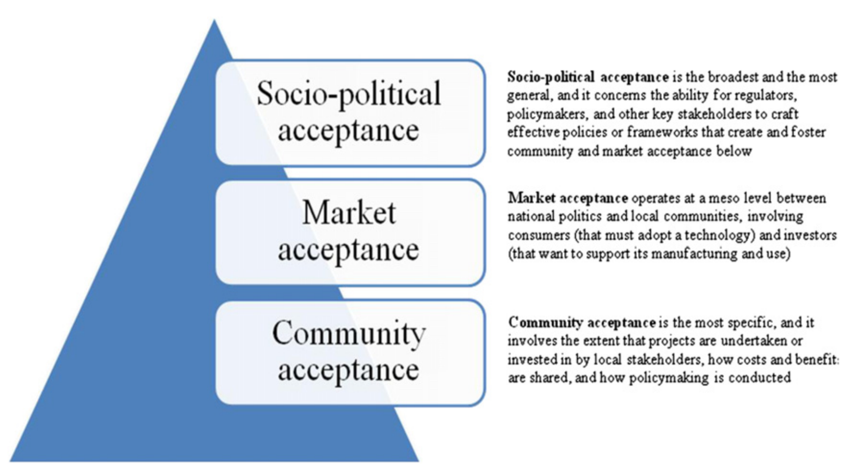

Fig. 1. Three dimensions of renewable energy acceptance.

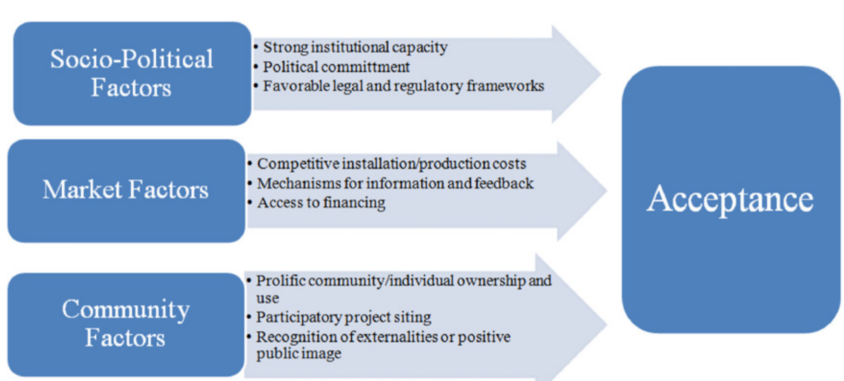

Fig. 2. Dimensions and conditions of socio-political, community, and market acceptance.

Table 1
Nine criteria fostering the acceptance of wind and solar energy.

Dimension	Criteria	Explanation
Socio-political	Strong institutional capacity	Countries exhibit institutional support at the national level through ministries or departments of energy with specific programs or subsectors dedicated to renewable energy, or have government sponsored institutes doing research on renewable energy
Socio-political	Political commitment	Political leaders make promoting renewable energy a highly visible topic
Socio-political	Favorable legal and regulatory frameworks	Laws and regulations facilitate easy of entry into the renewable energy market, independent renewable energy producers (even homeowners) are granted access to the electricity grid, national interconnection standards exist, and regulatory changes occur in a predictable and transparent manner
Market	Competitive installation/production costs	Renewable energy technologies can produce electricity at a competitive rate compared to other sources of supply, driven by government incentives, a large resource endowment, and/or a strong local manufacturing base
Market	Mechanisms for information and feedback	Investors and users/producers have access to reliable information about renewable energy policies, prices, and opportunities
Market	Access to financing	Producers, manufacturers, and users have access to domestic sources of low cost financing and/or can benefit from specific government financing schemes
Community	Prolific community/individual ownership and use	Renewable energy systems tend to be installed, owned, and/or or used locally
Community	Participatory project siting	People and communities are involved in the decision to site or permit renewable energy facilities near them
Community	Recognition of externalities or positive public image	Community members are generally aware of the environmental impact of conventional energy and the benefits of renewables, cultivating a strong public image

are favored among producers and users; it could be that other energy options such as fossil fuels and nuclear power are *disliked* whereas stakeholders are apathetic towards renewable energy (i.e., it's not that John Q. Public likes or even accepts wind energy, he just hates the thought of another coal plant, meaning wind "wins" by default). So it's important to remember that acceptance for us is always situational and comparative.

Fourth, for the sake of simplicity we have treated each of our criteria as equal. It may be that some criteria are truly more meaningful and influential than others. Strong institutional frameworks and access to financing may be true "knockout" criteria that are always needed for acceptance whereas countries without consistent political commitment and participatory project siting may still create frameworks generally conducive to acceptance. Further research ought to perhaps "weigh" our criteria through conjoint choice analysis, clustering, or other techniques to create a hierarchy of importance. We have not done so here for lack of space.

In essence, we propose that when our nine criteria are right, all three forms of acceptance occur and the diffusion of renewable energy will occur; conversely, when the conditions are lacking or weak, market deployment and acceptance is stunted. To test our theory, the next section explores the salience of these nine factors in explaining the adoption (or non-adoption) of residential solar panels in Germany and the United States and commercial wind farms in Denmark and India. It must be emphasized that each of the case studies presents a static picture, and also that we selected case studies to typify and exemplify our conceptual criteria. We would expect most countries to fall in between, rather than laying at either extreme.

4. Four case studies

As this section demonstrates, solar PV in Germany and commercial wind energy in Denmark meet most of our criteria for social acceptance, each home to robust markets for those technologies. As Table 2 shows, Germany satisfies every criterion except for *competitive installation/production costs* and Denmark satisfies every criterion except for that of *transparent regulatory changes*. The United States and India, by contrast, satisfy only three of our criteria, and are therefore home to less successful markets and less diffusion.

4.1. Residential solar PV in Germany

Even though Germany receives much less solar radiation and energy than other locations, it led the world market in both the use of solar electricity domestically and the manufacturing of solar photovoltaic cells in 2008. About one-quarter of the total world market for residential solar PV systems is installed in Germany, and the industry has grown significantly in the past few years, jumping from a turnover of about €1.6 billion in 2004 to more than €7 billion in 2008 and a total capacity exceeding 3700 MW (See Fig. 3).

Germany displays *strong institutional and regulatory frameworks* and *political commitment*. Before East and West Germany were united in 1990, the German Democratic Republic relied almost entirely on domestic coal for electricity generation, aiming to be self sufficient. This commitment to fossil fuels underwent a "fundamental shift" because of German unification, a strong anti-nuclear and pacifist movement, pride in engineering innovative technology, and a policy culture of strong government intervention. Unification of Germany "kept the conventional utilities and energy companies preoccupied so that they did not resist the first feed-in tariff, passed in the early 1990s." Attempts to locate a permanent nuclear waste repository and "a resistance of the German people towards nuclear weapons and atomic energy" in the country provoked an aggressive anti-nuclear movement, a movement whose influence "heightened extensively after Chernobyl, particularly in Southern Germany and Bavaria which were actually affected with fallout, with some people stopping to eat fresh food and refusing to go outdoors for weeks." National "pride in engineering and technology, especially the motif of the local German inventor experimenting and improving technologies, laid a strong foundation for research in solar energy." And, lastly, a "history of a strongly regulated Germany economy" facilitated acceptance of various measures – feed-in tariffs, subsidies, targets, other incentives – to promote residential solar panels.

As such, Germany exhibits a *favorable legal and regulatory framework*. The paradigmatic example is the most recent feed-in tariff law, the EEG, passed in 2000. Built into this law "was acknowledgement that the government wanted to create a long-term, stable policy platform to jumpstart investments in renewable energy." In 2004, legislators amended some of the tariffs to make them more precise based on technology, location, and size, and in 2009 some of the rates, especially those for solar panels,

Table 2
The degree of social and market acceptance for renewable electricity in Germany, United States, Denmark, and India.

	Germany	United States	Denmark	India
Strong institutional capacity	✓	✓	✓	✓
Political commitment	✓			✓
Favorable legal and regulatory frameworks	✓		✓	
Competitive installation/production costs			✓	
Mechanisms for information and feedback	✓	✓	✓	✓
Access to financing	✓	✓	✓	
Prolific community/individual ownership and use	✓		✓	
Participatory project siting	✓		✓	
Recognition of externalities or Positive public image	✓		✓	

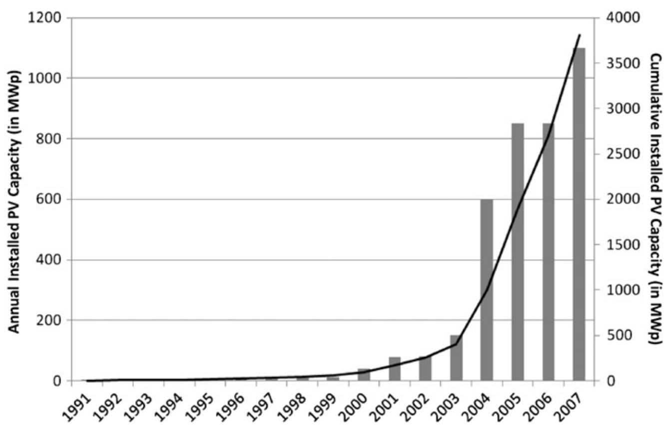

Fig. 3. Growth of the German Solar PV Market, 1991 to 2007.

were reduced in order to prompt lower production costs, but overall the regulations in Germany have been geared towards incentivizing solar energy. Regulations in Germany also encourage open market entry and access. Laws in Germany, for example, state that "grid system operators shall immediately and as a priority connect plants generating electricity from renewable energy sources," including residential solar panels. This means that incumbent firms or transmission and distribution operators cannot refuse any single actor from interconnecting and then selling their electricity to the grid.

Residential solar electricity generation in Germany is still not yet as cheap as the retail market rate for electricity, meaning its *production costs* are *uncompetitive* with alternatives such as fossil fuels, nuclear, and wind. However, although solar systems do not currently satisfy this criterion, it is expected that they will soon. As one respondent put it, "the German FIT locks in solar producing facilities today that sell their electricity at an elevated market rate, but due to rising electricity prices, and falling solar prices, grid parity will soon be reached, a point where solar costs will fall below the market rate."

Mechanisms for information and feedback have been established by the German government, with information available to those wishing to invest in their own solar energy systems on government websites, in brochures, and even "published for free in newspapers." Central to this information campaign are the tariffs that homeowners and others would receive if they did decide to invest in solar energy, tariffs that are calculated "to give every investor, down to the smallest household, a 6 percent return on their investment each year, meaning most solar systems pay for themselves quickly."

Access to financing is also available for Germans wishing to deploy solar panels. The German feed-in tariff scheme, apart from giving certainty to investors, also lowers the risk involved with financing renewable energy systems. As one respondent put it, the "guaranteed tariffs for solar electricity lower risk and therefore need less capital acquired at lower interest rates … leading to better market conditions for building and deploying them."

Prolific community ownership has been occurring in Germany. The original feed-in tariff passed in 1990 forced utilities to install renewable energy outside of their service area if they wished to benefit from it, resulting in some competition and the interactions between electricity suppliers and other communities. Unions played a strong role in framing solar energy manufacturing "as a way to promote local growth and local jobs," and "most solar panels are owned by residences, with more than 90 percent of panels operated by homeowners, cooperatives, and communities, not big energy companies or utilities." Indeed, if the numbers from interview respondents are to be believed, at the end of 2007 more than 430,000 solar panels had been installed on homes and buildings around the country, a growth of "more than 1000-fold from the 3 MW installed in 1991.

Germany has exhibited *participatory forms of project siting*, with energy policy decisions often made "at the local level" and with "numerous stakeholders, including trade unions, environmental groups, and consumer advocates all taking part." As another respondent explained, "many decisions about solar energy and renewable energy more broadly are made through a series of meetings and hearings that involve not only experts and policymakers but also selected members of the public and interest groups, creating a more inclusive environment."

Lastly, a general *recognition of* the *environmental benefits* of solar power has created a positive *public image*. The cost savings and avoided greenhouse gas emissions from solar PV have been passed onto consumers and society at large. As one respondent put it, the "accelerated penetration" of solar panels and other renewable energy systems has "benefitted the Germany people by displacing fossil fuel imports and lowering electricity prices" instead of concentrating benefits among particular companies or interests. Again, if the numbers mentioned by respondents are accurate, the overall feed-in tariff scheme for solar and other renewables cost about €3.3 billion in tariffs but saved them €9.4 billion in 2006. One respondent noted that all of these benefits were captured by an initial increase on electricity bills "the equivalent of a cup of coffee or a loaf of bread per family," or less than €6 per month.

4.2. *Residential solar PV in the United States*

The market for solar photovoltaics in the United States is the fourth largest in the world, but such a claim is misleading. The bulk of solar PV installations in the country are not integrated into buildings or configured for homes, but owned and operated by utilities and power providers in large and centralized installations. Also, more than three-quarters of the *entire* U.S. market for solar PV is in one state, California, and per capita use is very low at

2.3 W (See Table 4 at the end of the paper) [24]. The United States has a total capacity of grid-connected solar of 478 MW, more than 100 times less than Germany [29]. In terms of our analytical criteria, the United States meets only three: *strong institutional capacity, mechanisms for information, and access to financing.*

The U.S. does demonstrate *strong institutional capacity* for solar energy (and renewable energy). Although the country does not manufacture most of its own panels and instead imports them from abroad (including Japan and Germany), the country had a large and ambitious research program in the 1970s and established the Solar Energy Research Institute, the predecessor to the National Renewable Energy Laboratory. One respondent noted that this attempted to "make solar energy in the image of nuclear power, and so it failed to promote small-scale and residential applications." Still, respondents suggested that the state of technology in the U.S. was "good" with "high standards for quality" and a corresponding "decent market for solar panels and companies wanting to install and maintain them."

Political commitment and *favorable regulatory frameworks* have been lacking. As a consequence of the oil crises of the 1970s, President Jimmy Carter did promote solar energy as part of his major energy initiatives, and the passage of the Public Utility Regulatory Policies Act (PURPA) of 1978 had far-reaching consequences for small-scale energy systems. PURPA offered incentives for the use of decentralized solar panels and established the first production tax credits for such systems. Further commitment at the national level for solar energy occurred with the passage of the Energy Policy Act of 1992, Energy Policy Act of 2005, and the Energy Independence and Security Act of 2007, supplemented by a flurry of state efforts including renewable portfolio standards, but overall policy has been consistent.

For instance, federal research on solar energy systems has focused on centralized, large-scale and utility owned technologies whereas legislation has advanced decentralized, small-scale, and independently owned technologies. Legislation including the 1935 Public Utility Holding Company Act (PL 74–333), 1980 Wind Energy Systems Act (PL 96–345), 1984 Renewable Energy Industry Development Act (PL 98–370), and provisions of the Energy Policy Act of 1992 (PL 102–486) were allowed to expire or never fully implemented. The result, as one respondent put it, has been "completely unpredictable and inconsistent mandates, less research on solar energy, and higher electricity prices for American customers." One study found that energy policy in the United States was the most inconsistent out of a sample of 17 countries [13]. Another respondent indicated that the only consistent characteristic of U.S. energy policy has been to "promote the cheapest and least cost resources first."

Moreover, utilities and transmission operators have been able to "oppose independent interconnection or access to the grid without extensive feasibility studies or exorbitant insurance rates." As one interview respondent explained, "utilities are by nature monopolistic entities that had a charter to provide adequate energy capacity, with near total control over the production of electricity with little responsibility for cost," and they do not want to "lose control over their market." Regulated utilities almost "instinctively fight against companies that provide electricity from alternative sources," and "such institutions, which have become a powerful political force because of their market power, are reluctant to change their existing technologies and see the market share of these technologies dwindle."

Changes to national energy policy have also not been consistent or predictable. The paradigmatic example is the production tax credit for wind and solar energy, which "has abruptly expired at least four times over the past two decades." Another participant indicated that changes to policy often "come out of nowhere and are about as predictable as how many bad television shows Paris Hilton will appear on next year, which is to say, it's not predictable at all."

Like Germany, solar panels do not *produce electricity competitively*. One respondent claimed that they even "generated electricity more expensively than in Germany, although the U.S. has more sunlight, since the technology in Germany and economies of scale are better."

However, the United States does satisfy the criterion of *information and feedback*. As of March 2009, net metering was available in 47 states. Net metering enables consumers to sell electricity back to the grid and is usually coupled with real time or time-of-use prices, meaning consumers know almost instantly how much electricity costs them for a given moment as well as how much value they get from selling that electricity back to the grid. Because some renewable resources produce electricity when it is valued the most, such as a solar panel powering the grid at 2 pm on a hot summer day, net metering systems (when coupled with time-of-use rates) can enable them to receive credit for this more expensive power. Under two of the most successful net-metering regimes, customers in California and New Jersey had installed more than 23,000 distributed solar systems, collectively, by early 2008. Net metering has been described as "providing the most significant boost of any policy tool at any level of government to decentralize American energy resources."

The country also offers *access to financing*, although its effectiveness has been offset by the inconsistency mentioned above. Still, a national investment tax credit applies to residential installations of solar panels and other renewables and has been extended to 2016. In addition, several U.S. states also offer grants, rebates, and/or tax credits for solar panels, and these "have significantly lowered the cost of financing and procuring systems compared to what they might otherwise be."

Incentives for community and individual ownership are largely absent in the United States. Large, investor owned utilities and companies operate most of the country's renewable electricity capacity, and one participant estimated that "less than 10 percent of the solar systems in the United States are probably owned by actual individual people." Indeed, one recent study from the National Renewable Energy Laboratory on the effectiveness of policy mechanisms for solar panels argued that policies have been completely *ineffective* at promoting small-scale, residential applications [25].

Participatory forms of project siting and energy policymaking do sometimes occur, but the overall trend has been in favor of leaving important decisions to "experts, technocrats, and bureaucrats." Consequently many individuals do not find solar panels aesthetically pleasing and oppose them in their local communities. One participant mused that "watching a solar panel produce electricity is about as exciting as watching toast burn." Another commented that solar panels were so unpopular in their community that their neighbors would "rather invest in things like upgrading kitchen cabinets, new showerheads, or even bird baths instead of putting solar panels on their roof."

Lack of recognition and understanding about the environmental benefits of solar energy further complicate efforts at diffusion. This is "partially the fault of electricity ratemaking structures in the U.S, which are biased in favor of conventional utilities and against independent homeowners and third parties." For example, public utility commissions and regulators typically set retail electricity rates based on a combination of utility revenue (including administrative, financial, and marketing costs), operating expenses (including personnel, fuel, purchased power, and maintenance charges), and recovery of capital investment (plant and equipment committed to public service less depreciation). A percentage profit, or rate of return, on all investments is often included in electricity rates. Thus, "the costs from energy systems

are basically invisible to most users and homeowners—they merely do not think about solar energy at all."

4.3. Commercial wind energy in Denmark

Denmark currently leads the world in terms of exportation of wind energy technology, with a hold on roughly one-third of the world market for wind turbines, and has the largest portfolio of wind projects integrated into their power grid of any country in the world (more than 20 percent). Some parts of the country, such as Western Denmark, frequently supply more than 40 percent of their electricity from wind turbines, and the country's wind capacity increased six-fold from 1996 to 2003 (See Fig. 4). These achievements are all the more impressive when readers consider that the country is roughly the same size and population as the state of Maryland in the U.S.

Danish government policy has reflected a *strong institutional capacity* for wind energy. The Danish Ministry of Energy, established in 1979, supported wind technology by first promoting an investment subsidy that gradually declined as costs fell, and then implementing feed-in tariffs, financing, streamlined permitting, and a carbon tax. Danish policy also promoted broad involvement and participation at virtually all levels of the wind industry, including stakeholders in discussions not only about the siting and permitting of wind turbines but also in owning wind farms and contributing to the design of wind technologies.

The only criterion Denmark did not meet was *political commitment*. In 2001, the government "abruptly switched" from their time-tested method of using set feed-in tariffs to promote wind and other renewables to a tendering system for large-scale offshore parks that some participants called "inconsistent," "ineffective," and "worrisome." Participants noted that current prices are too low and have stunted wind growth. For example, from 2004 to 2006, developers installed less than 40 MW of capacity, compared to more than 500 MW (and often more than 1000 MW) annually before the changes were made. A new energy policy agreement among the political parties in the parliament is expected to adjust the tariff upwards in order to meet the 2025 goals set out by government, but this has been a long time coming and its passage is "highly uncertain."

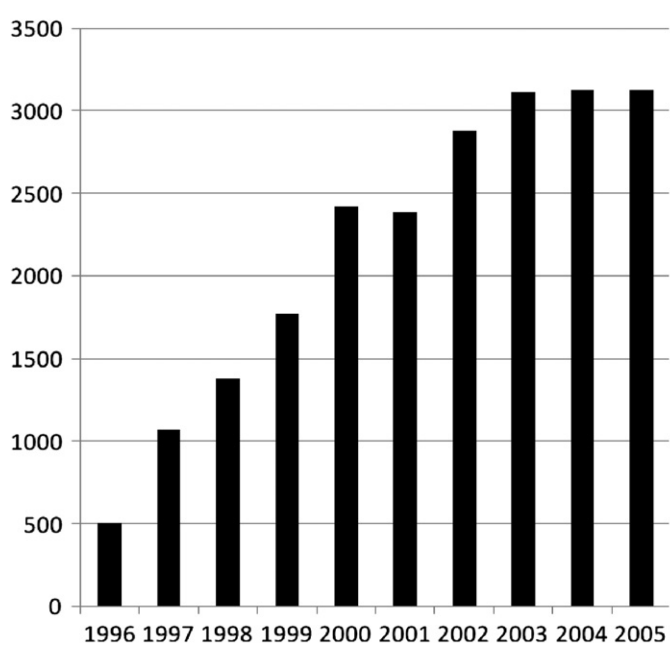

Fig. 4. Growth of Danish commercial wind capacity, 1996 to 2005.

Despite this recent uncertainty, for the most part the country still has *favorable legal and regulatory frameworks*. In Denmark, grid connection costs for wind energy are "shared among power providers and electric utilities/transmission operators." Wind turbine owners bear the costs of interconnection whereas utilities must cover all costs relating to transmission access and reinforcement of the distribution grid. Danish Transmission System Operators are legally obligated to finance, construct, and operate the transformer stations and transmission and distribution infrastructure for centralized wind farms and decentralized wind turbines owned by ordinary people. They are obligated to connect wind power and expand the grid if necessary, and provide financial compensation if any of the wind power generated was curtailed. The costs of this infrastructure investment and reimbursement for curtailed power were paid for by the government, and then distributed to all customers.

At the foundation of Denmark's wind strategy have also been sustained taxes on energy fuels, electricity, and carbon dioxide, which both create incentives for energy efficiency and provided government revenue for wind research. These energy related taxes sent price signals that encouraged energy efficiency measures in the Danish power market, and accrued government funds for research expenditures that they directed at wind power, biomass, and small-scale combined heat and power units. Such taxes "have ensured that the costs of renewable energy research are borne equally by society and electricity customers, which is appropriate since the benefits of wind energy, such as displaced imports, better jobs, and economic competitiveness, have also been shared by society."

Based partly on strong winds and favorable topographic conditions, as well as a robust domestic manufacturing hub, *installation and production costs* for wind energy in Denmark are *competitive*. As one respondent stated, "even though wind turbines generate electricity intermittently, and have a capacity factor below 40 percent, they still generate electricity more cheaply than most coal and fossil fueled plants in Denmark." Said another, "since wind farms can be completed much quicker than other types of power plants, and are not reliant on imported and carbon-intensive fuels, they are highly competitive in the Danish electricity market." According to participants, from 1980 to 2005 the cost per kW h of Danish wind turbines decreased 60 to 70 percent and Danish wind turbines now produce 180 times more electricity at 20 percent the cost.

Denmark encouraged *information sharing and feedback* so that that the process of "learning-by-doing" became "learning-by-interacting." Institutions such as the Association of Danish Wind Power Owners and the Association of Danish Wind Mill Manufacturers emerged to promote information sharing so that multiple direct learning points were established among thousands of wind energy users who were incentivized to provide critical inputs and contributions. This "interactive" model of feedback supported many small competitors working and creating variations of wind technology in a relatively small market, enabling them to address potential problems with blade design, structural dynamics, and introduction of light materials.

As Danish wind systems matured, the government supported expansion with *access to financing*. Starting in 1979, the Danish government promoted an investment subsidy that reimbursed individuals, municipalities, and farming communities for the capital cost of installing wind turbines. These subsidies initially covered 30 percent of expense of renewable energy systems but were scaled down periodically as the industry grew and turbine prices decreased. The Danish government also established the "Danish Wind Turbine Guarantee" in the 1980s to provide long-term financing of large wind projects that used Danish made

components, reducing the risk of building larger projects and encouraging local manufacturing.

Communal and individual ownership of Danish wind projects has been historically promoted rather than ownership concentrated in the hands of large corporations. This condition grew out of the long tradition of cooperatives in Denmark, as well as a grassroots interest in wind power that evolved during the 1970s. An "idyllic but still widely subscribed to vision" of a "self-sufficient local community" using wind turbines to generate electricity has had a "strong appeal among ordinary Danish citizens." As a result, many communities own and operate wind turbines themselves and many entrepreneurs are "do-it-yourself" builders. Participants indicated that almost 90 percent of wind farms were owned by individuals and cooperatives in 2007.

Danish political institutions have also incentivized *participatory methods of project siting*. The Danish political system is based on egalitarian ideals traced to the country's founding as an agricultural society, when medium and small farms occupied an overwhelming amount of land and the rural population was highly educated. This system of governance ensures that "many energy policy decisions, especially relating to wind farms, are made at the local, rather than national level," and they "result in high rates of participation among the Danish citizenry."

Such widespread use has created a *positive public image* for wind energy in Denmark. Danish researchers emphasized the importance of local ingenuity and skill in gradually scaling up turbine designs, "creating a product quickly associated with Danish culture and a strong brand presence." Government regulators picked up on this motif and managed public awareness campaigns painting wind energy as a way to "revitalize rural areas, strengthen Danish *kommunes* (communities), and make great returns on investment."

4.4. Commercial wind energy in India

India has tripled its commercial wind capacity from 2005 to 2009 and exceeded its national targets for wind energy for three consecutive years (See Figs. 5 and 6). India is the fifth largest wind power producer in the world [26–28], but it is uniquely different from the other prominent global players. Almost 99 percent of the wind power producers are private players. Furthermore, while the market is seemingly booming, wind farms are not widespread and wind generation per capita is miniscule fraction of that in Denmark (See Table 4 presented in the conclusion of the paper).

Much of the credit for the growth of the wind energy sector in India has been due to *strong institutional capacity* and *political commitment* both at the State and Central Government level. "Tax

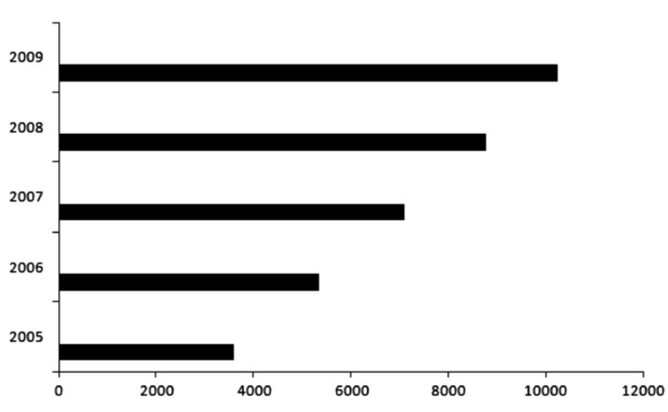

Fig. 5. Installed capacity of wind power in India.

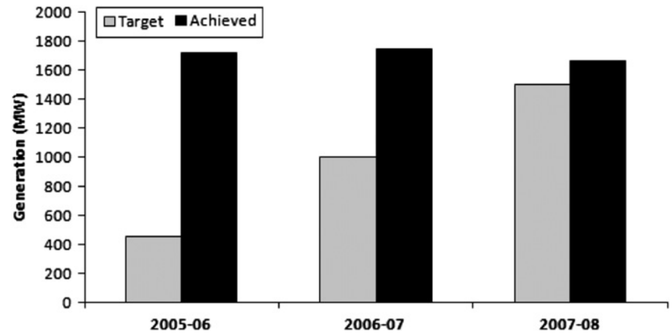

Fig. 6. Comparison of actual achievement vs. Planned targets for wind energy in India.

and financial incentives coupled with opportunities for captive consumption or sale of power to the utility have provided the necessary market environment", noted one participant. In order to create a more favourable environment for wind power, several new mechanisms are being considered, such as production tax credits (PTC) and renewable energy certificates (REC), which can be classified as production based incentives (PBI). "These mechanisms," another participant stated, "create a totally distributed risk environment… [where] one can expect to conceive large projects, with the right economies of scale and access to capital at a lower rate, thereby increasing the viability of projects."

Yet despite such capacity and commitment, *regulatory frameworks* retain many *unfavourable* aspects for wind energy. Grid connectivity remains one of the main barriers. "Most of the wind rich States in the initial phases of development had good and stable grids and transmission lines and this was an important factor for new investors who were taking a risk on new technology and new sites", according to one of the respondents. Over the last few years however, grids and transmission lines in India have been unable to keep up with the rapid growth of wind power installations. As one respondent put it, "Technical potential of wind power in India is 13,000 MW as compared to a gross potential of 45,000 MW and unless grids and evacuation of power is stabilized, this potential may never be harnessed". Moreover, third party sales give producers the opportunity to earn higher tariffs and give them more certainty on payments, but are currently constrained. It is the general opinion that, "If open access was allowed in more States then this would help tremendously in lower payback periods and also improve State contracts due to the element of privatization and competition."

Production costs for wind energy have been *uncompetitive*. One unique feature of the Indian market is that most manufacturers undertake wind projects on a turnkey basis. European partnerships in turbine technology, however, have translated into high capital costs for the investor, delayed proper maintenance, and left India without a robust indigenous manufacturing sector. It has also meant that many turbines built for the European market do not function well (and have higher operating costs and shorter lifetimes) because their tower hub heights are too low and they cannot handle voltage fluctuations on the Indian grid. As one participant from an investment firm observed, "indigenous manufacturing also brings with it cautiousness about reliability and sustainability, as Indian firms have a shorter track record when compared to their European or American counterparts". Thus, a lack of local manufacturing and "disadvantaged location has been one of the greatest limitations to the development of wind energy projects", states an owner of a wind turbine. Another commented that "most of the potential wind power sites are located in areas where infrastructure facilities are virtually

non-existent and more needs to be done if the sector has to succeed."

However, voluntary associations such as the Indian Wind Power Association, The Indian Wind Turbine Manufacturers Association and the Indian Wind Energy Association have played an integral role in providing *information and feedback* to producers, manufacturers and other stakeholders. A respondent noted that, "this proactive interaction acts as system of checks and balances," and such associations provide information on regulation and tariffs as they are being formulated in the various States in India as well important lessons learned from wind energy development other countries. Another respondent commented that "these organizations provide an excellent platform for producers and manufacturers to address common concerns and issues". The Central Government has taken certain initiatives as well by setting up the Center for Wind Energy Technology (C-WET) to disseminate information on wind data, sites and approvals for turbines.

Access to financing for producers and manufacturers coupled with financial and preferential taxation incentives "would be ideal for this comparatively nascent industry to survive," one participant commented, yet have not been available on a large scale in India. During the early stages of the sector's development in the 1990s, the Indian Renewable Energy Development Agency (IREDA) was the only available source of subsidized financing for wind power producers. IREDA continues to play an important role, but there is a need for local Banks and financing institutions to offer similar funding options to producers. "There is an urgent need for differential sources of financing as the profile of wind power producers in the country vary. Securitization of Power Purchase Agreements and a 'Project Finance' model as compared to relying on the underlying company's balance sheet, would be advantageous", observed one respondent. Another respondent remarked that, "Manufacturers too must have facilities provided by locals and community banks than relying only on Export Credit Agencies and expensive foreign sources of funding."

Community ownership of wind farms is virtually non-existent in India. A representative from one of India's premier wind power Associations observed that, "In developed countries there is either a strong push from the Government to have citizens use electricity generated through renewable sources or there is a strong interest from the consumer's side to use green power. In India, at the moment, there is neither." Although participants commented that "community ownership could be a novel way of distributing costs and benefits amongst the investors as well as helping small and medium farmers have access to power," such forms of ownership are not prevalent in the Indian wind sector.

Another limiting factor is lack of *participatory project development*. Much of the land suitable for wind power generation is owned by the Government. These wind sites are typically inhabited by farmers practicing agriculture. Under the turnkey model, manufacturers procure the land from the Government on behalf of the wind power producer. The local communities are not consulted during this process and it has often led to considerable discontentment. "We have had roads leading to the wind site blocked by local communities, components stolen from the turbine and other incidents" mentioned a manufacturer. "Although local communities have historically not been involved in the decision making process," noted one participant, "it has become increasingly important to have a participatory form of project implementation and have local communities involved.",. More recently, local communities have expressed their concerns and sought clarifications through their respective village level governing councils. State Government and private corporations have been supportive of this move and it is hoped that the process will gain momentum in the future.

India does not display an environment conducive to *recognition of environmental benefits* and in some ways wind turbines there have a *negative public image*. The wind power producers are predominantly the only beneficiaries in this sector. Benefits are not passed onto consumers or other stakeholders. Revenues earned through the sale of carbon credits to European buyers are providing a much needed additional source of income for the wind farm owners, but so far hardly any of this money has reached communities. They thus sometimes view wind energy as a blight on their land, as something to be opposed or perhaps tolerated, but not embraced.

Table 3
Examples of renewable energy acceptance in Germany, United States, Denmark and India.

Criteria	Example(s)
Strong institutional capacity	India has a national ministry of new and renewable energy The National Renewable Energy Laboratory in the United States and Risø National Laboratory in Denmark conduct research on various aspects of solar and wind energy
Political commitment	Parliamentarians Herman Scheer and Hans-Josef Fell staunchly support renewable energy as a way to revitalize the East German economy after unification Political parties in Denmark continually announce ever-more ambitious targets for wind energy in order to build a robust domestic manufacturing base
Favorable legal and regulatory frameworks	Rules in Denmark force transmission system operators to connect all renewable electricity generators to the grid independent of its cost Changes to the German feed-in tariff scheme occur transparently every four to five years with input from a broad spectrum of stakeholders
Competitive installation/ production costs	Germany rewards renewable energy producers with a premium tariff above the retail market price for electricity Local production and manufacturing of wind turbines in Denmark lowers installation costs, enhances learning, and reduces risk
Mechanisms for information and feedback	Net metering in most states in the U.S. allow solar and small-scale wind producers to sell electricity back to the grid at real-time prices, making peak production more valuable Germany publishes information about policy mechanisms such as the feed-in tariff in newspapers and through free brochures
Access to financing	Various U.S. banks and government programs offer preferential financing opportunities for residential solar systems The Danish government designed and promoted a "Danish Wind Turbine Guarantee" that offered financing for projects using Danish made materials and components
Prolific community/individual ownership and use	Ninety percent of commercial wind farms in Denmark are owned by local cooperatives and individuals Roughly half a million families have installed solar panels on their homes in Germany
Participatory project siting	Trade unions, environmental groups, nongovernmental organizations, community leaders, and consumer advocates are all involved in German renewable energy permitting
Recognition of externalities or positive public image	*Kommunes* in Denmark enthusiastically embraced wind energy as an environmentally friendly alternative to nuclear power Renewable energy in Germany is credited with displacing fossil fuel imports and lowering volatile electricity prices in Germany

Table 4
Comparison of U.S. and German solar PV markets and Danish and Indian wind energy markets.

Country	Number of commercial wind farms (2008)	Number of grid-connected systems (2007)	Total installed capacity (MW) 2008	Population 2008 (Million)	Installed capacity per capita 2008 (W)
Germany	–	430,000	5400	82.37	65.6
United States	–	13,516	478	304.06	2.3
Denmark	169	–	3180	5.48	579.8
India	25	–	9650	1147	8.4

5. Conclusion

In this paper, we have proposed that nine factors create conditions where socio-political, community, and market acceptance of renewable electricity technologies will occur. Countries that exhibit a combination of (1) strong institutional capacity, (2) political commitment, (3) favorable legal and regulatory frameworks, (4) competitive installation and/or production costs, (5) mechanisms for information and feedback, (6) access to financing, (7) prolific community and/or individual ownership and use, (8) participatory project siting, and (9) recognition of externalities or positive public image will see market acceptance grow and diffusion occur; countries where these conditions are lacking will see growth and diffusion stall. Indeed, Table 3 explains how these nine factors do a reasonably well job of predicting and explaining the rapid acceleration of solar panels in Germany and commercial wind turbines in Denmark, the moderate to slow growth in India and the United States. As Table 4 depicts, the United States has almost 30 times less solar capacity installed per capita than Germany, and Denmark has almost 70 times more commercial wind capacity per capita than India. Indeed, it may be that these criteria are applicable to the acceptance of other energy technologies, and could be explored in the context of coal, natural gas, oil, and nuclear systems.

More specifically, the research interviews and primary data collected for this article suggest that the simultaneous presence of almost *all* nine factors in Germany have enabled the country to become the world leader in solar PV production and use. The United States, by contrast, has an amount of installed grid connected solar capacity 100 times less than Germany and meets only three of our conditions. Denmark, like Germany, leads the world in commercial wind energy exports and has the largest percentage of wind capacity integrated into its electricity sector and meets all but one of our criteria, whereas India has seen moderate but by no means exceptional growth of their wind sector.

An interesting outcome of this comparative case study is being able to understand what India and the United States can do to enhance market acceptance and embark on a pathway similar to Denmark and Germany.

The United States has reliable technology (it used to lead the world in wind electricity generation until it was overtaken by European countries), a decent network for information exchange and knowledge dissemination, and beneficial sources of financing and procurement for wind power operators. However, political regulations have been inconsistent and often biased in favor of fossil fuels and nuclear sources of electricity supply, and ownership of wind farms remains concentrated in the hands of corporate players and large-scale electric utilities. Decision-making is isolated and often confined to experts and public officials, and regulatory changes have been unexpected and damaging to the sector. Costs and benefits of wind generation are typically consolidated among companies rather than communities, and significant barriers remain relating to grid access and interconnection.

India needs to develop indigenous sources of technology and have better access to potential wind sites as a first step. There has been some momentum in the sector with the advent of Indian companies such as Suzlon energy entering the fray, but the market is still dominated by European joint ventures. India also has to pay more attention to participatory forms of project siting and provide incentives for community ownership. Apart from benefitting stakeholders who are currently marginalized, this will also empower citizens to make more responsible decisions in choosing renewables over fossil fuel based generation. Lastly, for full potential to be realized India has to address issues such as grid connectivity and other market barriers which are impeding the growth of the sector. India has already set a good precedent amongst developing countries in adopting wind energy, but must capitalize on its moderate momentum by cultivating all nine factors from our framework.

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Appendix A. List of Institutions Contacted and Interviewed For Case Studies

Alliance to Save Energy (USA)
American Electric Power (USA)
ASEGI Incorporated (USA)
California Energy Commission
California Independent System Operator (ISO)
Cambridge Energy Research Associates (USA)
Dong Energy (Denmark)
EA Energlananalyse (Denmark)
Ecotope Consulting, Research, and Design (USA)
Edison International Company (USA)
El & Energi (Denmark)
Electric Power Research Institute (USA)
Enercon (Germany)
Enercon (India)
EnergiNet DK
Energy Trust of Oregon (USA)
European Association for Renewable Energy (London)

Exelon Corporation (USA)
Fraunhofer-Institut für Solare Energiesysteme ISE (Germany)
German Aerospace Center
German Solar Industry Association (BSW-Solar)
Global Wind Energy Council (Brussels)
Grontmij / Carl Bro (Denmark)
Gujarat Energy Development Agency (India)
Gujarat State Electricity Board (India)
Hazel Capital LLP (United Kingdom)
Iberdrola (Spain)
Idaho National Laboratory (USA)
Indian Ministry of Environment and Forests
Indian Ministry of New and Renewable Energy
Indian Ministry of Power
Indian Renewable Energy Development Agency
Indian Wind Energy Association
Indian Wind Turbine Manufacturers Association
Ingersoll Rand Company (USA)
Karnataka Power Transmission Corporation Limited (India)
Lawrence Berkeley National Laboratory (USA)
LM Glasfiber (Denmark)
Maharashtra Energy Development Agency (India)
Maharashtra Energy Regulatory Commission (India)
Maharashtra State Electricity Board (India)
MBD Offshore Power A/S (Denmark)
National Academies of Science (USA)
National Commission on Energy Policy (USA)
New York State Department of Public Service
New York State Energy Research and Development Authority
Nextant Incorporated (USA)
Niras (Denmark)
Oak Ridge National Laboratory (USA)
Optimal Energy Consulting (USA)
Orbicon (Denmark)
Pareto Energy Limited (USA)
Pew Center on Global Climate Change (USA)
Primary Energy (USA)
Ramboll Denmark A/S
Risø National Laboratory (Denmark)
Solar-Fabrik AG (Germany)
Southern California Edison (USA)
State Corporation Commission of Virginia
Suzlon Energy (India)
Tamil Nadu Electricity Regulatory Commission (India)
Tamil Nadu Energy Development Agency (India)
Tamil Nadu State Electricity Board (India)
The Energy Resources Institute (India)
The Open University (United Kingdom)
The Stella Group, Inc. (USA)
U.S. Department of Energy
U.S. Energy Information Administration
U.S. Environmental Protection Agency
United Nations Environment Programme (London)
United Technologies (USA)
University of Birmingham (United Kingdom)
University of California Berkeley (USA)
University of Illinois at Chicago (USA)
University of Tennessee (USA)
University of Virginia (USA0
Vermont Energy Investment Corporation (USA)
Vestas (Denmark)
Vestas Wind Technology India Pvt. Ltd
Virginia Center for Coal and Energy Research
Virginia Department of Environmental Quality
Virginia Department of Mines, Minerals, and Energy
Virginia Polytechnic Institute & State University
World Bank Group (United States)
World Future Council and United Kingdom
World Future Council Belgium
World Future Council Germany
Worldwatch Institute (USA)
Zentrum fur Sonnenenergie-und Wasserstoff-Forschung Baden-Wurrtemberg (ZSW) (Germany).

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